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EARTH RESOURCES TECHNOLOGY SATELLITE
FINAL REPORT

10. SOLDERING PROGRAM PLAN

PREPARED FOR

GODDARD SPACE FLIGHT CENTER
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

UNDER CONTRACT NAS5-11260

TRW SYSTEMS GROUP

IBM FEDERAL SYSTEMS DIVISION

Itek OPTICAL SYSTEMS DIVISION

EARTH RESOURCES TECHNOLOGY SATELLITE

FINAL REPORT

Volume 10. Soldering Program Plan

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prepared for

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PREFACE

The final report for the ERTS Phase B/C study consists of the 12 volumes that are submitted now and additional volumes to be delivered in April covering the results of the study of the Ground Data Handling System for ERTS. The contents of the first volumes of the report are as follows:

Volume

1. (to be completed in April). Summarizes all significant conclusions of the study and indicates where the supporting analyses are presented. The system specification is included as an appendix.

2. (to be completed in April). Contains all system interface studies.

3. Describes the design of ERTS resulting from the study, to a block diagram level of detail.

4. Presents the detailed results of the study supporting the design in Volume 3, including backup tradeoffs and analyses.

5. Presents both the design of the data collection system and the supporting analyses.

6-12. Present the plans prepared for the ERTS Phase D program on the Phase B/C program.

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CHAPTER 1: BASIC PRINCIPLES

3A100 Scope

1. This plan describes hand and machine soldering requirements for reliable electrical or electronic connections. For the purposes of this document, the definitions in Appendix A shall apply. This document sets forth the manner in which TRW Systems Group will comply with NHB 5300.4 (3A), Requirements for Soldered Electrical Connections. TRW's approach in meeting the NHB requirements are specifically identified by vertical bars appearing at the margin.

2. This document does not include specific requirements or specifications for the subjects listed below; however, these subjects are discussed in the paragraphs indicated as they relate to the requirements of this document. Subcontracts and purchases citing this publication or NHB 5300.4 (3A) shall contain detailed TRW Process Specifications (PR) requirements to cover these items where applicable, including provisions for materials and applications suited to the intended use and environment.

   Special storage and handling (para. 3A307)

   Wire insulations, sleeving (para. 3A308, 3A610)

   Ultrasonic cleaning (para. 3A311)

   Terminals (para. 3A312)

   Special parts mounting requirements (para. 3A500)

   Potting compounds (para. 3A504)

   Cordwood modules (para. 3A504)

   Integrated circuits (para. 3A505)

   Connection without terminals (para. 3A608)

   Printed wiring (para. 3A800)

   Conformal coating (para. 3A800)

Magnification (para. 3A703, 3A805, 3A905)

Clean room requirements (para. 3A301)

3A101 General

1. It is understood that NASA Quality Assurance personnel will advise and assist contractors, suppliers, NASA personnel, and delegated agencies in the proper and effective implementation of the provisions of this document.

2. Where related requirements or changes in requirements are required, it is understood that NASA Quality Assurance personnel will ensure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instructions so that the work will be inspected to the actual contract requirements.

3. Unless parts are fabricated specifically to comply with subcontracts or purchases citing this publication, internal connections of parts (as parts are defined in Appendix A) are not subject to the requirements of this publication. The supplier will assure himself that parts have suitable internal connections which will not unsolder or deteriorate when external connections are made by his processes.

3A102 Related Documents

1. Applicable Specifications. The following specifications are applicable on this program:

   QQ-S-571 – Solder, Tin Alloy; Lead Tin Alloy; and Lead Alloy

   MIL-F-14256 – Flux, Soldering, Liquid (Rosin Base).

   Unless otherwise specified, the issue in effect on the date of invitation for bids or request for proposal shall apply.

2. Reference Publication. The Fourth Edition, NASA SP-5002 "Soldering Electrical Connections," is a reference document only. Detailed soldering requirements will be as set forth in this document and in program approved TRW specifications.

3A103 Deviation and Waiver Requests

This publication will require:

1. Written approval of the cognizant NASA contracting officer or his designated NASA representative, for technical changes, deviations (as defined in Appendix A) and waivers.

   Technical changes and deviations will be submitted as stated above except where a technical change is documented by a drawing or specification change. Documented repairable workmanship nonconformances from the requirements of this publication (variations as defined in Appendix A) may be dispositioned by Material Review Board action, or by Government-approved Standard Repair Procedures, as applicable.

2. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality will not be compromised.

3A104 Rework

Rework, as defined in Appendix A, is permissible unless excluded by other provisions of the contract, and shall meet the requirements of this publication. Rework is not repair. Repair shall be made only in compliance with applicable contractual requirements as a result of Material Review Board action, or in accordance with Government-approved Standard Repair Procedures.

CHAPTER 2: SUPPLIER SOLDERING PROGRAMS

3A200 General

TRW Systems Group and associated subcontractors and suppliers, herein referred to as the supplier, will be responsible for maintaining a documented soldering program which meets the requirements of this publication for the types of solder connections utilized in the articles involved. Portions of this publication, including illustrations, may be abstracted for the program.

3A201 Training and Certification

The supplier is responsible for:

1. Providing necessary training of his personnel in the use of equipment employed and for ensuring that all personnel who perform or inspect soldering are adequately skilled to fabricate the types of soldered connections required.
2. Certifying all personnel who perform or inspect soldering as being currently qualified to fulfill all requirements of this publication pertaining to the types of connections to be soldered. Records or evidence of certification status shall be maintained.
3. Maintaining appropriate records of training, including the certification criteria for each individual's latest certification.

3A202 Maintenance of Certified Status

1. The procuring installation, its designated representative, or the supplier's instructor, may require supplier soldering personnel to demonstrate proficient workmanship on applicable hardware, or to be recertified.

3A203 Recertification

1. The need for recertification shall be based on observation of the unsatisfactory quality of articles fabricated, or interruption of work utilizing this skill, for more than 90 days.

2. Recertification shall be required when:

   a) Proficiency requirements herein have not been met, or certification has been revoked;

   b) New techniques have been developed which require different skills;

   c) One year has elapsed since certification/recertification; or

   d) There is reason to question workmanship of operators or inspection performance by inspectors.

3A204 Revocation of Certified Status

Certifications shall be revoked for operators or inspectors when:

1. Certificate holder requires recertification according to paragraph 3A203 and fails to be recertified.

2. Supplier training program fails to meet requirements as set forth herein or otherwise in the contract.

3. Certificate holder leaves employment.

4. Certificate holder fails to meet visual acuity requirements of paragraph 3A205.

3A205 Vision Requirements

1. The supplier is responsible for ensuring that all personnel who perform soldering or inspect soldered connections meet the following vision test requirements as prerequisite to training, certification, and recertification. Subsequent to the visual examination for certification or recertification, a visual examination will be required of all soldering certified personnel on an annual basis. The vision requirements may be met with corrected vision (eyeglasses). The eye tests shall be administered by qualified personnel, using standard instruments and techniques. Results of the vision examination shall be maintained and available for review.

2. The following are the minimum vision requirements:

   a) Far vision — Snellen Chart 20/50

   b) Near vision — Jaeger 1 at 14 inches; or reduced Snellen 20/20 or equivalent.

c) Color vision — Ability to distinguish red, green, blue and yellow colors as prescribed in Dvoring Charts, Ishihara plates, or AOD-HRR tests. A practical test, using color coded wires and/or color coded electrical parts as applicable, will be acceptable for color vision testing.

3A206 Workmanship Standards

The supplier shall:

1. Prepare visual standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for all soldered connections involved.
2. Utilize applicable illustrations in this publication, supplemented as necessary for visual standards.
3. For approved connections other than those illustrated herein, prepare appropriate visual standards.
4. Clearly illustrate by these standards preferred workmanship and the difference between acceptable and unacceptable workmanship.
5. Make applicable visual standards readily available to concerned personnel and use them in the training program.
6. Use these standards for inspection criteria and evaluation of personnel performance.

3A207 Documentation

1. This program plan will be submitted to the procuring NASA Installation or its designated representative for review. Appendix B is TRW's Electronic Systems Division Standard Operating Procedure 2.10.1, Training Program NASA Soldering, which implements the requirements of this section.
2. The supplier shall document, and maintain said documentation on a current basis. The training and certification program he proposes to satisfy the requirements herein for the types of solder connections he will make. This documentation shall include the following:

   a) Qualification of instructors

   b) Procedures for training

c) Lesson plan(s)

d) Hours of instruction

e) Procedures for certification and recertification.

3. The supplier shall document the fabrication and inspection procedures he proposes to satisfy the requirements of this publication. Appendix C, Fabrication/Inspection Process Procedure, FIPP 7-18-02, entitled "Discrete Component Installation and Soldering to Terminals," is an example of an operating document implementing the requirements of this plan and TRW Process Specifications.

CHAPTER 3: FACILITIES, EQUIPMENT AND MATERIALS

3A300 Facility Cleanliness

The supplier is responsible for maintaining soldering areas in a clean, orderly condition. Smoking, eating and drinking at the work stations shall not be permitted.

3A301 Environmental Conditions

1. The soldering area shall have a controlled environment which limits entry on contamination. This area shall be continuously controlled as follows:

Temperature	$75 \pm 10^{\circ}F$
Relative humidity	Max 60%

2. In field operations, and where soldering under controlled conditions is impractical, adequate precautions shall be taken to maintain the required quality of solder connections.

3A302 Lighting Requirements

Light intensity shall be a minimum of 100 foot-candles on the work surface.

3A303 Tool and Equipment Control

The supplier shall:

1. Select tools and equipment used in soldering, and in preparations thereto, for intended function.
2. Properly clean and maintain equipment and tools.
3. Document or reference, in the supplier's soldering program, detailed operating procedures (see Appendix C).
4. Maintain records of tool calibration and verification.

3A304 Heat Sources

1. Supplier Responsibility. The supplier shall:
   a) Choose a means of applying heat to the metals to be joined which is compatible with the size, shape, and thermal conductivity of the work pieces.

b) Provide in operating procedures for cleanliness of the heat source to ensure uniform heat transfer and prevent contamination of the solder connection.

c) Forbid use of soldering guns.

2. Resistance-Type Soldering Electrodes. The surfaces of electrodes shall be kept free of dirt and corrosion.

3. Conduction-Type Irons. The tip shall be periodically checked for:

a) Proper insertion

b) Tight attachment

c) Cleanliness

d) Tinned surface on the tip working surface to ensure proper heat transfer and to prevent transfer of impurities.

4. Noncontact Heat Sources. When soldering heat is applied by a jet of heated gasses, or by radiant energy beams, the supplier shall set up, operate, and maintain the equipment by established, documented procedures.

3A305 Conductor Preparation Tools

The supplier shall select and use conductor preparation tools as follows:

1. Select insulation strippers and lead bending tools which do not nick, ring, gouge or scrape conductors or damage parts (see Figures 3-1 and 3-2 for typical devices).

2. Select part lead cleaning tools which do not damage leads and parts and which do not cause contamination and hinder solder wetting (see Figure 3-3 for typical devices).

3. Use the correct size of stripping tools or machines and maintain them in calibration.

4. Verify, periodically, insulation strippers and lead bending tools for proper operation.

5. Remove defective or uncalibrated tools and strippers promptly from the work area.

3A306 Thermal Shunts

Thermal shunts or heat sinks shall be utilized where heat from the soldering operation may degrade the quality of heat sensitive parts or of previously soldered connections (see Figure 3-4 for typical devices).

3A307 In-Process Storage and Handling

The supplier is responsible for proper storage and handling and providing means to prevent contamination of printed wiring termination areas, terminals, wire ends, or part leads during handling and storage. Containers compatible with materials stored are required. When handling of bare copper surfaces is unavoidable, white gloves or finger cots shall be used.

3A308 Materials Selection

The supplier is responsible for selecting materials suitable for intended use which do not degrade the quality of the solder junction and metals or parts being joined.

3A309 Solder

Solder shall conform to Federal Specification QQ-S-571, type RA or RMA for cored solder; and type S, form B or I for solid solder. It shall be composition Sn60 – Sn63, unless otherwise required by a NASA-approved design.

3A310 Flux

1. Types and Usage. The supplier's process documentation shall describe the types of fluxes, where each is used, and necessary precautions.

2. Liquid Rosin Flux. Liquid rosin flux shall conform to MIL-F-14256, type A, except that the copper mirror test (para. 3.5) is not required, and that the resistivity of water extract (para. 3.2.6) shall be at least 45,000 ohm-centimeters. Liquid flux used with flux-cored solder shall be chemically compatible with the solder core flux and with the materials with which it will come in contact.

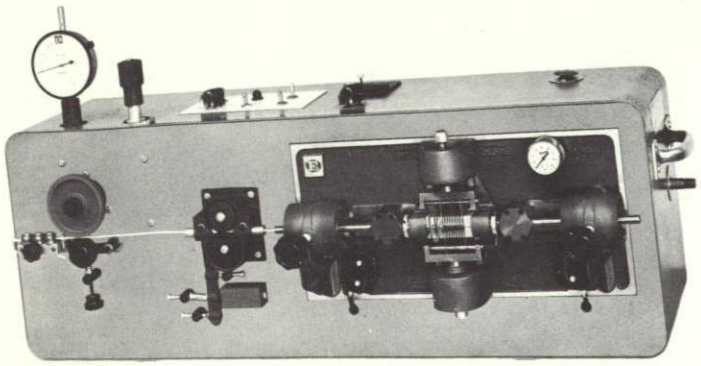

Figure 3-1
TYPICAL THERMAL STRIPPER

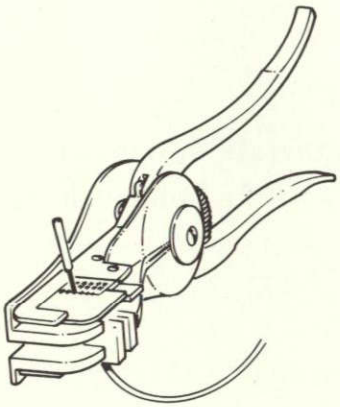

Figure 3-2
TYPICAL PRECISION CUTTING-TYPE STRIPPER

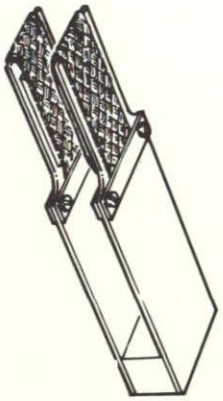

Figure 3-3
TYPICAL COMPONENT LEAD CLEANING TOOL

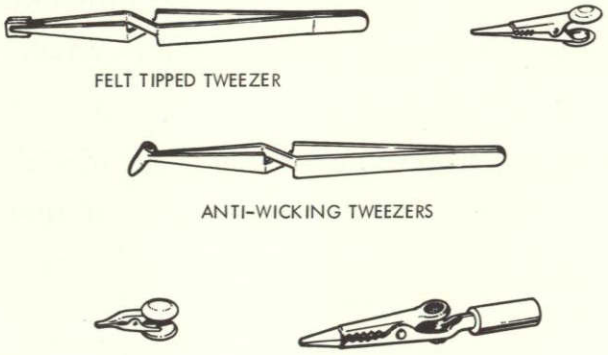

Figure 3-4
TYPICAL THERMAL SHUNTS

More active flux may be used for tinning difficult to tin surfaces. This active flux shall be used only prior to tinning and shall not be used for fluxing final solder connections. In addition, such fluxing operation shall be followed by a specific flux neutralization procedure.

3A311 Solvents

1. A list of solvents proposed by the supplier for cleaning and flux removal shall be submitted for review. Solvents shall be nonconductive, noncorrosive, and shall not dissolve or degrade the quality of parts or materials.

CAUTION

Solvents shall not be used in any manner which will carry dissolved flux residue onto contact surfaces such as those in switches, potentiometers, or connectors.

2. The following solvents are acceptable when properly used for cleaning in soldering operations:

   a) Ethyl alcohol, ACS grade, 99.5% or 95% by volume

   b) Isopropyl alcohol, best commercial grade, 99% pure

   c) Trichlorotorifluoroethane, 99.8% pure

   d) Any mixtures of the above

   e) Freon TMC followed by Freon TF

   f) Freon TE or TF.

CAUTION

Ultrasonic cleaning, if used, shall be employed with caution to prevent damage to parts.

3A312 Terminals

1. Solder terminals shall comply with the contractual specification or drawing.

2. Hot dipped, tin-lead coated terminals are preferred. Terminals with uneven or excessive coating on the mounting surfaces shall not be used as they may loosen in subsequent soldering operations.

3. Terminals shall be of proper size to accommodate the conductors. Terminals and conductors shall not be modified to accommodate improper sizes.

4. The use of silver-plated terminals on printed circuit boards shall not be permitted.

CHAPTER 4: PREPARATION FOR SOLDERING

3A400 Preparation of Conductors

1. Insulation Removal. Insulation shall be removed from conductors by use of thermal strippers or precision cutting-type strippers. The equipment employed shall be of the correct size for the wire used and in current adjustment and/or calibration.

2. Damage to Insulation. After stripping, the wire shall be examined for insulation damage such as crushing or charring. Wires with damaged insulation shall not be used. However, slight discoloration from thermal stripping may be acceptable.

3. Damage to Conductors. After stripping, wire shall be examined with a magnifying glass (5X to 10X), where practicable, to ensure that the wires have not been stretched, nicked, cut, scraped, or otherwise damaged. Wires having any of these defects shall not be used.

4. Arranging Stranded Wire Lay. Stranded wire shall be twisted in the direction of the lay during stripping operation in order to maintain its original form after stripping. Bare finger contact must be avoided.

5. Conductors. Conductors or part leads shall not be reduced in cross-sectional area. Gold plated part leads and solid wire leads shall be pretinned immediately prior to attaching. No solvent shall be permitted under the insulation. Flux shall be applied so that it does not go under the insulation except for traces carried up by solder wicking.

6. Tinning of Stranded Conductors. Stripped ends of stranded wires shall be tinned to prevent untwisted and separation of wire strands.

7. Wicking. Flow (wicking) of solder along the conductors is permitted up to the point of insulation termination, but shall not obscure the wire contour at the termination end of the insulation.

3A401 Preparation of Terminals and Solder Cups

Terminals shall be examined and, where necessary, cleaned with an approved solvent prior to wire attachment and soldering. Oxidized terminals shall not be used.

3A402 Additional Requirements

1. Solid Hookup Wire. Solid hookup wire shall not exceed a length of one inch between supports. For wires over one inch in length, attachment to a surface by conformal coating is adequate support.
2. Stress Relief. All wires and leads terminated at a soldered connection shall have sufficient slack in the form of a gradual bend to minimize stresses during thermal expansion. In applications where multiple wires are routed from a common cable trunk to equally spaced terminals, the stress relief shall be uniform to prevent stress on any one wire (see Figure 4-1).

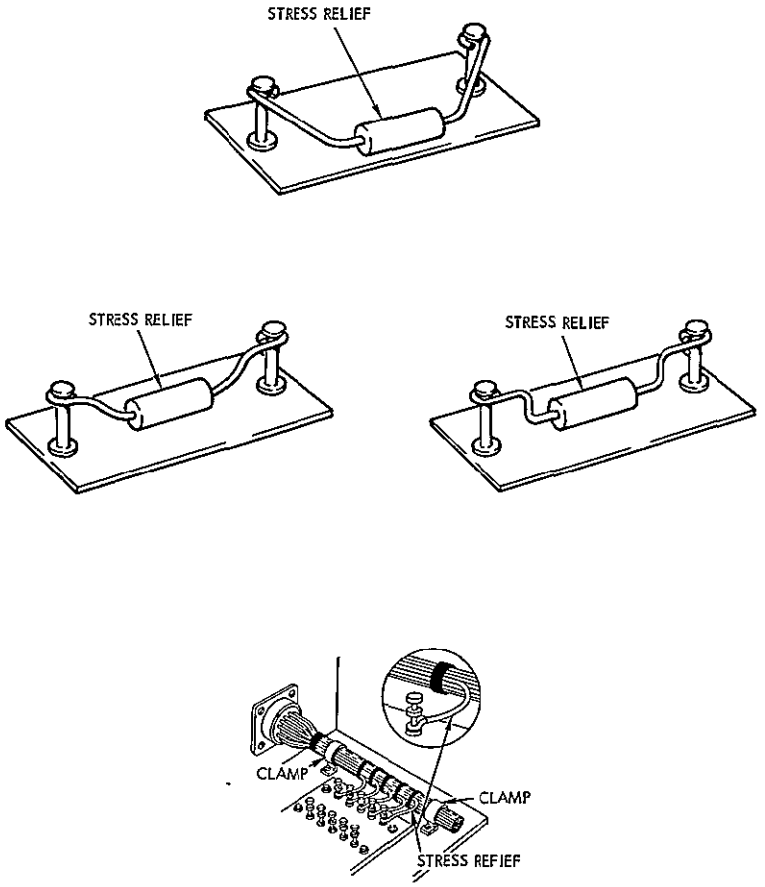

Figure 4-1

TYPICAL EXAMPLES OF STRESS RELIEF

3. Mechanical Support. Solder joints shall not be subjected to mechanical loads. Mechanical support shall be provided for components or wire bundles by clamping, potting, embedding or other means to prevent stresses on the solder joints.

4. Splicing. The splicing or wires shall not be allowed unless authorized by engineering documentation, Standard Repair Procedures, or Material Review Board action.

CHAPTER 5: PARTS MOUNTING

3A500 General Requirements

1. Unless otherwise specified or approved by the procuring NASA installation, parts shall be mounted parallel to, and in contact with the mounting surface.

2. Irregularly Shaped Parts. When the shape of parts is such that only point contact can be made with the mounting surface, additional support shall be provided.

3. Heavy Parts. Parts which weigh more than 1/2 ounce (14 grams) shall be supported. Design requirements shall specify method of support or attachment, i.e., potting, clamp, etc.

4. Metal Case Parts. Except for transistors mounted on transipads, all metal case parts mounted over printed conductor wiring or which can come in conflict with each other or with other conductive material, shall be insulated with transparent tubing. These parts shall not be mounted over solder connections.

5. Glass Encased Parts. When using epoxy potting compound to encapsulate glass encased parts (e.g., diodes), the parts shall be enclosed in transparent resilient sleeving or coating material prior to mounting and encapsulation for protection against thermal expansion.

3A501 Lead Bending Requirements

1. General. During bending or cutting, part leads shall be supported to minimize axial stress and avoid damage to seals or internal bonds. The inside radius of the bend shall not be less than the lead diameter. The distance from the bend to the end seal shall be approximately equal at each end of the part. The minimum distance from body to bend shall be two lead diameters. Where the lead is welded (as on a tantalum capacitor) the minimum distance is measured from the weld (see Figure 5-1).

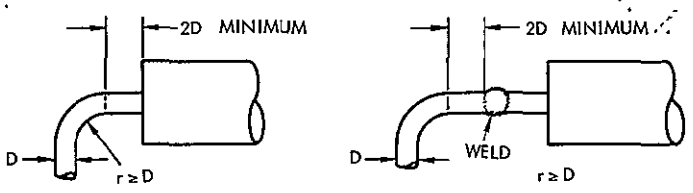

Figure 5-1

MINIMUM LEAD BEND

2. Nonclinched Leads. Part leads which are not bent and clinched flush with the circuit shall be properly cleaned and cut to a length that will permit the lead to extend 1/32 to 3/32 inch through the board. The contour of the end of the conductor shall be discernible after soldering (see Figure 5-2).

3A502 Lead Clinching, Printed Wiring Boards

1. General. When clinched the clinched lead shall not extend beyond the conductor pattern edge. The clinch shall not be forced to make the conductor lie flat at the bend radius. The innate spring-back of the part lead is acceptable (see Figure 5-3).

2. Rounded Termination Areas. The leads shall extend through the board a minimum of the termination area radius, and a maximum of two times the termination area radius, and shall be clinched in the direction of the conductor pattern.

3. Irregularly Shaped Termination Areas. For irregularly shaped termination areas, such as for shield and around plane connections, the minimum clinch lead length shall be twice the diameter of the lead hole, and the maximum shall be four times the hold diameter.

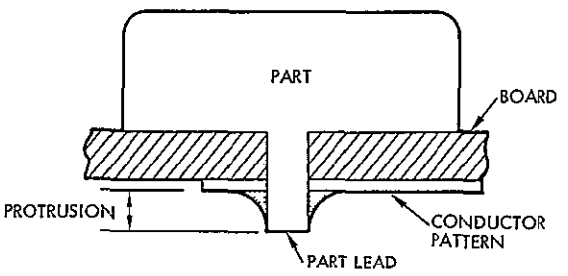

Figure 5-2

NONCLINCHED LEAD

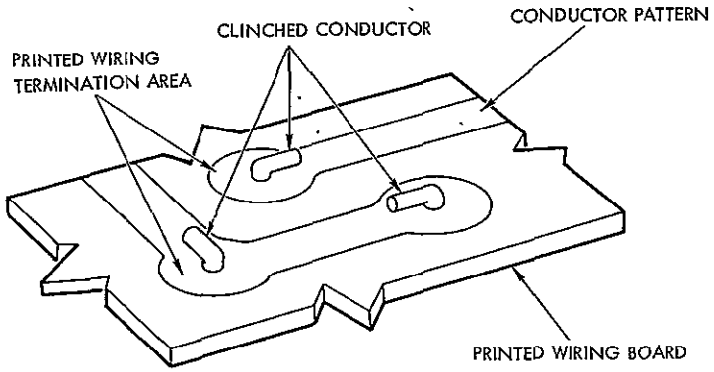

Figure 5-3
EXAMPLE OF CLINCH DIRECTION

3A503 Mounting of Parts to Terminals

1. The length of leads between parts and terminals shall be approximately equal at both ends, except when special part shapes, such as flanges on tophat diodes, require staggering.
2. Each lead shall have a provision for stress relief.
3. Degree of wrap, routing, and connection to terminals are specified in Sections 6 and 7.

3A504 Cordwood Modules

1. Parts in cordwood modules shall be mounted with the part axis perpendicular to the two parallel printed wiring boards, as space permits.
2. Tubular parts shall be uniformly spaced between the printed wiring boards.
3. Coated parts shall be mounted so that coating on leads does not enter the mounting hole.
4. Terminations of part leads shall be as specified herein, except when they are extended to serve as straight pin terminals, or as connections to the board on which the module is mounted.

5. Leads of heat sensitive parts shall not be used as straight pin terminals.

6. The selection and application of potting compound and the use of clinched or unclinched lead terminations shall be specified on design engineering and/or materials and process documentation and made available to the procuring NASA installation for review.

3A505 Mounting of Flat Pack Circuits

1. The mounting of integrated circuits, "flat packs," may be by lap solder joints to termination areas on the wiring side of the boards.

2. Process specifications or fabrication procedures shall specify the method for making internal connections.

CHAPTER 6: ATTACHMENT OF CONDUCTORS TO TERMINALS

3A600 General

1. Conductors shall be attached to terminals as illustrated in this section, which show the requirements for routing to terminals, terminal fill, insulation clearance, and the extent of conductor wrap or bend.

2. For terminals not described or illustrated herein, similar procedures to accomplish the same intent shall be documented on internal documentation, i.e., engineering/process specifications, available for review by the procuring NASA installation.

3A601 Wire Termination

1. Breakouts from Cables. For multiple wires routed from a common cable trunk to equally spaced terminals, the length of the wire ends, including vibration bend allowance, shall be uniform to prevent stress concentration on any one wire.

2. Minimum Insulation Clearance. The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.

3. Maximum Insulation Clearance. The maximum insulation clearance shall be less than two wire diameters including insulation, but in no case shall permit shorting between adjacent conductors.

4. Multiple Parallel Entry. For multiple parallel entry of wires to a terminal, insulation clearances need not be equal.

5. Variations. When characteristic impedance or circuit parameters are affected, such as in high voltage circuits or coaxial line terminations, the insulation clearance requirements may be modified. All variations shall be documented in engineering documentation which shall take precedence over other requirements.

3A602 Turret and Straight Pin Terminals

1. Side Route. The side route shall be used on all solid post turret type terminals with connections made as follows. (see Figure 6-1).

   a) Conductor sizes AWG 26 and smaller shall be wrapped a minimum of 1/2 turn to a maximum of one full turn around the post.

   b) Conductor sizes larger than AWG 26 shall be wrapped a minimum of 1/2 to a maximum of 3/4 turn around the post.

   c) For turret terminals, all conductors shall be confined to the guide slots. (A second conductor on the lower or upper guide slot is permissible)

2. Bottom Route. The conductor shall enter the terminal from the bottom, be routed through the side slot at the top of the terminal, and wrapped as required for the side route shown in Figure 6-1.

3A603 Bifurcated Terminals

1. General. Top, side, bottom routes, or combinations as illustrated in this section are permissible. Terminal side route connections shall not extend beyond the top of the terminal.

2. Bottom Route. Wires shall terminate with a 90-degree bend and shall be soldered to the terminal shoulder. Conductors shall not extend beyond the diameter of the base except that a 180-degree bend around the terminal post is acceptable when physical clearance is adequate for the intended environment and electrical

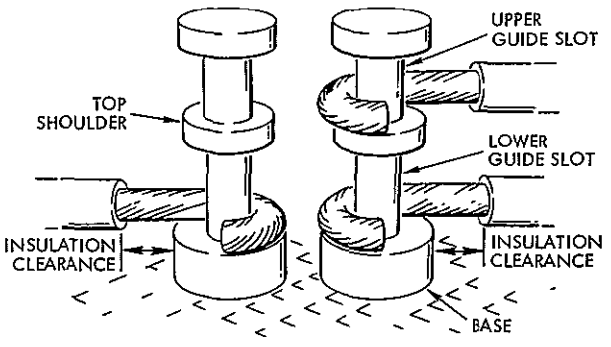

Figure 6-1

TURRET TERMINAL

characteristics. The insulation clearance shall be measured from the point of entry of the wire into the terminal (see Figure 6-2).

3. Side Route. The wire shall enter the mounting slot at a right angle and terminate with a 90-degree bend. Conductors shall not extend beyond the diameter of the base except that a 180-degree bend around the terminal post is acceptable when physical clearance is adequate for the intended environment and electrical characteristics. When more than one wire is connected to the terminal, the direction of the 90 degree bend on each additional wire shall alternate. The first wire shall be soldered to the base and the vertical post. Additional wires shall be soldered as close as possible to the preceding wire. The insulation on the first wire and all additional wires shall be a uniform distance from the terminal posts. Insulation clearance shall be referenced from the base (see Figure 6-3).

4. Top Route. Top route shall be connected as shown in Figure 6-4. Conductors which fill the gap between the terminal vertical posts shall be inserted to the depth of the shoulder. Conductors which do not fill the gap shall be accompanied by a tinned filler wire (solid or stranded) to help hold the conductor in position or shall

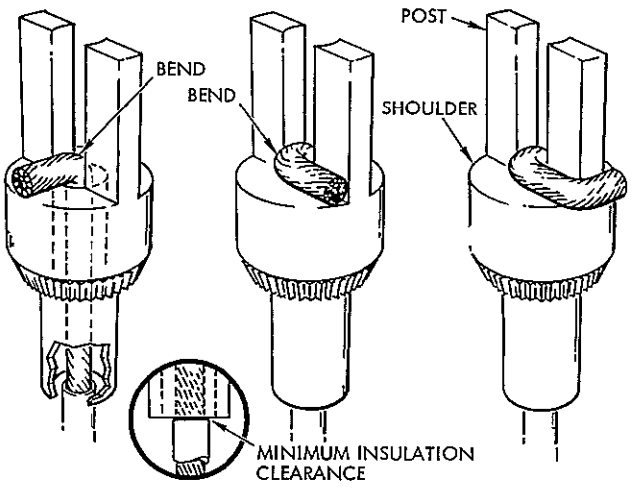

Figure 6-2

BOTTOM ROUTE CONNECTION ON BIFURCATED TERMINAL

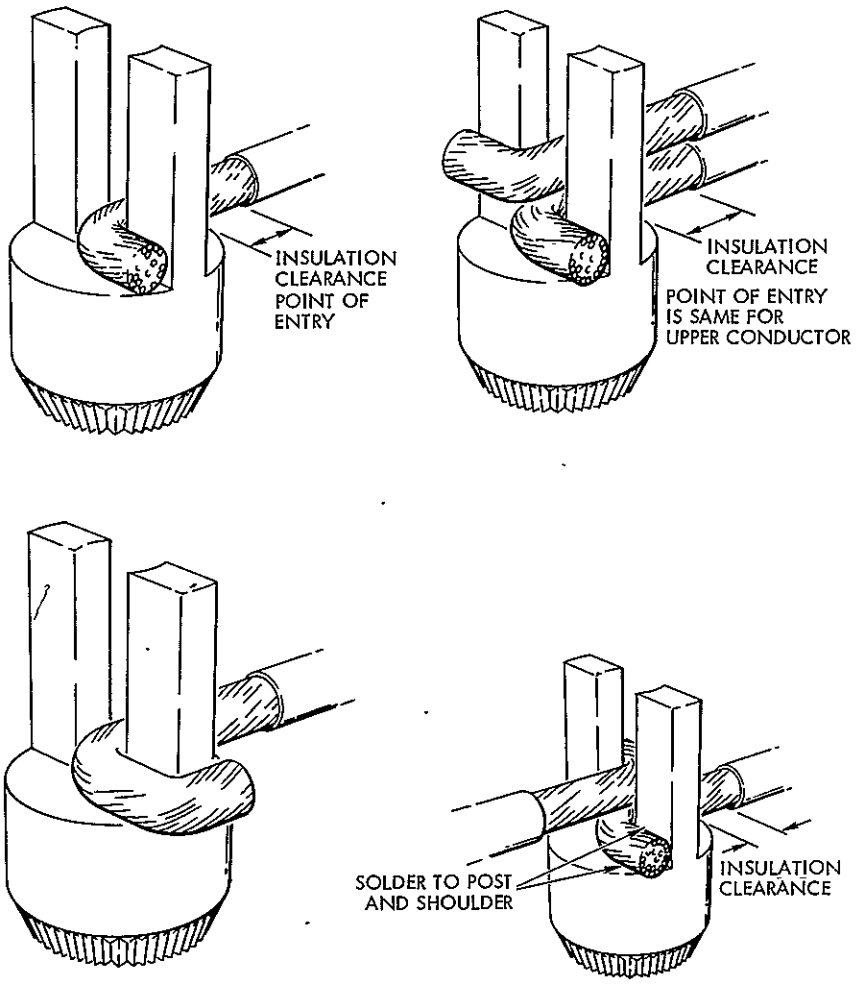

Figure 6-3

SIDE ROUTE CONNECTION TO BIFURCATED TERMINAL

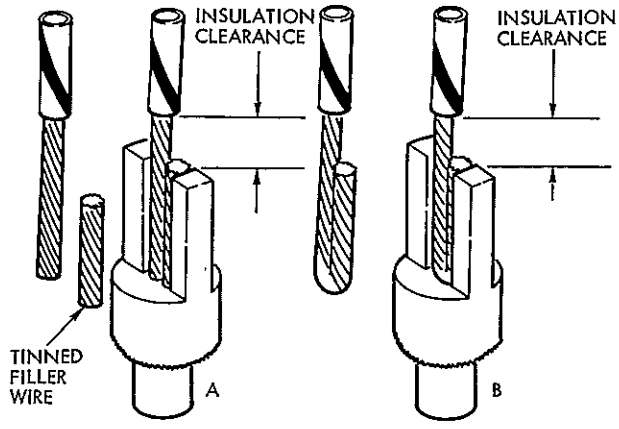

Figure 6-4

TOP ROUTE CONNECTION ON BIFURCATED TERMINAL

be bent double as shown, provided the combined diameters are sufficient to fill the gap. The top route and side route shall not be used on the same terminal. The top route shall not be used if there is sufficient room for side entry. Insulation clearance shall be measured from the point of entry into the terminal.

5. Top and Bottom Route. The bottom route shall be installed first as shown in Figure 6-2, then the top route as shown in Figure 6-4, with the top route conductor bottoming on the bottom route conductor.

6. Side and Bottom Route. The bottom route shall be installed first as shown in Figure 6-2, then the side route as shown in Figure 6-3.

3A604 Hook Terminals

Connections to hook terminals shall be as shown in Figure 6-5. The bend to attach conductors to hook terminals shall be a minimum of 1/4 turn to a maximum of 3/4 turn. Conductors to hook terminals may approach from any angle for connections, provided the soldering is in the hook portion of the terminal. Protrusion of conductor ends shall be limited to avoid damage to insulation sleeving where used. Insulation clearance shall be as illustrated.

3A605 Pierced Terminals

Connections to pierced (perforated) terminals shall be as shown in Appendix C. The bend to attach conductors to pierced terminals

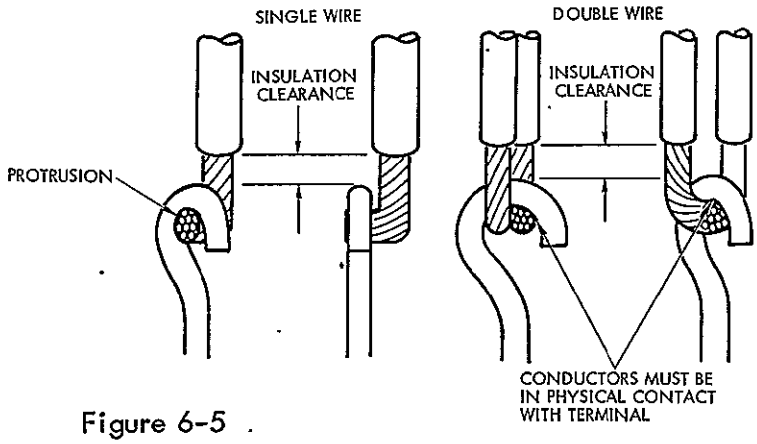

Figure 6-5
CONNECTIONS TO HOOK TERMINALS

shall be a minimum of 1/4 turn to a maximum of 3/4 turn. Conductors to pierced terminals may approach from any angle for connections, provided the soldering complies with the requirements of this section.

3A606 Solder Cups (Connector Type)

Conductors shall enter the solder cup as shown in Figures 6-6 and 6-7. The maximum number of conductors shall be limited to those which can be in contact with the full height of the inner wall of the cup.

3A607 Solder Cups (Swaged Type)

Conductors entering from the top shall be in contact with the inner wall of the cup and shall bottom in the cup or on the bottom conductor.

3A608 Connection Without Terminals

When solid conductors are approved by NASA to be used as straight pin type terminals, conductors shall be wrapped as specified in paragraph 3A602.

3A609 Lap Joints

A lap joint may be used for attaching conductors where space does not allow for bending the conductor. The joint will be properly documented and made available to the procuring NASA installation for review.

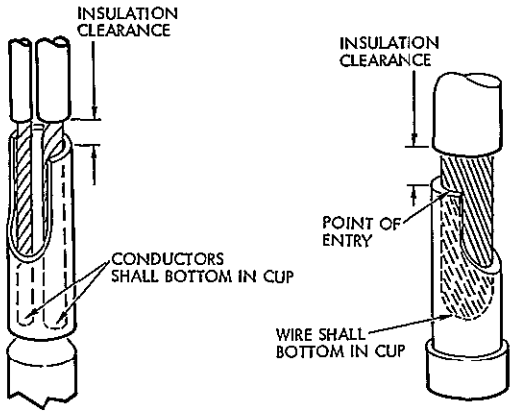

Figure 6-6
CONNECTION TO SOLDER CUP

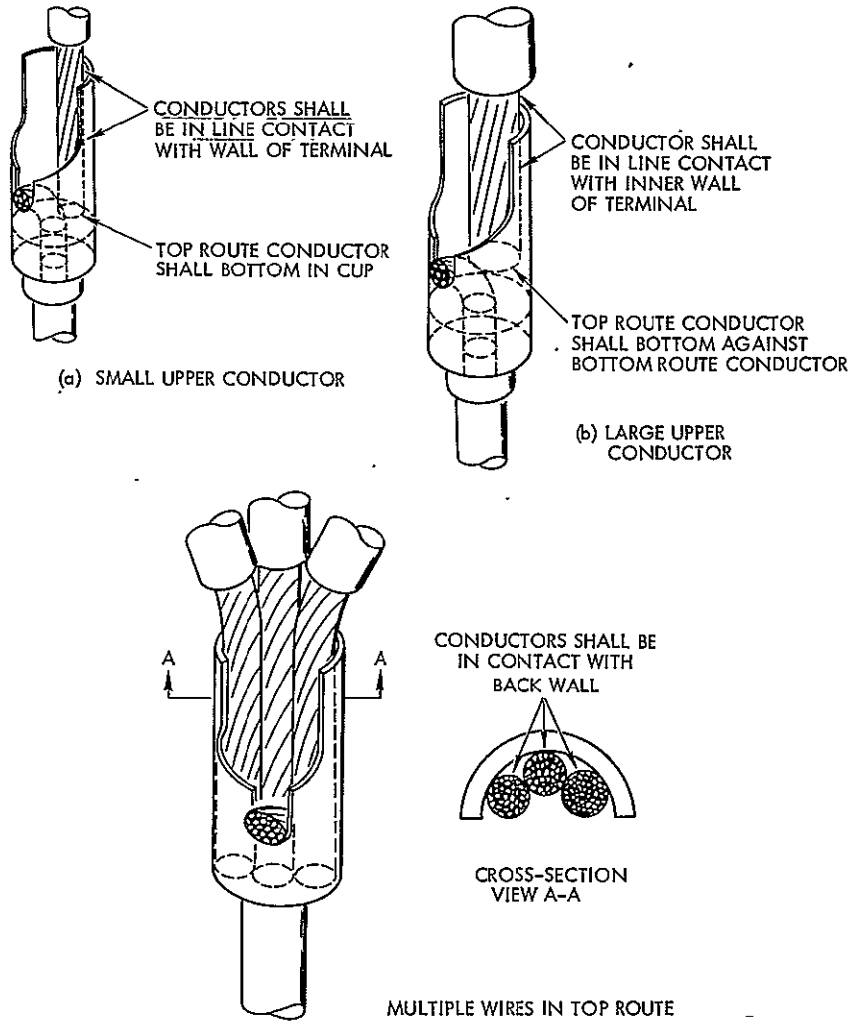

Figure 6-7

CONNECTIONS TO SWAGED-TYPE SOLDER CUPS

3A610 Insulation Tubing Application

Insulation tubing shall be used for mechanical and electrical protection of soldered joints, wires, and leads and to protect wire harnesses and conductors against abrasion. Insulation tubing shall:

1. Be installed over wires, leads, and harnesses prior to their attachment to terminals of relays, connectors, and similar items which are not protected by insulating grommets or by potting.
2. Be slid back far enough from the terminal so as not to interfere with the securing and soldering operations.

3. Be slipped back, after the solder has solidified, cooled and the joint cleaned, over the wires and terminals and where applicable, heat shrunk.

After installation, the tubing shall extend above the stripped portion of the attached conductor a distance equal to or greater than the tubing diameter.

CHAPTER 7: SOLDERING OF TERMINALS

3A700 General

1. Securing Conductors. Wire and leads shall be held snugly and rigidly to terminals in such a manner that there will be no motion relative to each other during the soldering operation, cooling, and solidification of the solder.

2. Insulation Sleeving, Potting or Coating. Protective coverings or coatings on the soldered terminals shall comply with requirements of the contract.

3A701 Solder Application

1. Swaged Terminals. Terminals swaged to a solid flat conductor shall be soldered to one surface of the conductor.

2. All Terminals Except Solder Cup. Sufficient solder shall be applied to form a concave fillet between the terminal and each side of the wire. The contour of the wire shall be visible after soldering. Excessive solder which completely covers the wire and terminal is not permitted. Terminals with more than one wire shall have each wire in contact with and soldered to the terminal.

3. Solder Cup Terminal. The solder shall completely fill the cup as a fillet when the solder is melted and the tinned wire is inserted to the bottom of the cup. The solder shall follow the contour of the cup entry slot. Spill-over or adherence to the sides of the cup is allowable to the extent that it does not interfere with the assembly or function of the connector.

   Connections may be made with either a resistance or conduction-type soldering iron. When a conduction-type iron is used, the slight tinned effect occurring at the point where the tip contacts the base of the cup is normal and shall not be cause for rejection provided there are no peaks, globules, or excessive buildup of solder.

4. Wicking. Flow of solder along the wire is permitted up to the point of insulation termination. Solder shall not obscure the contour of the conductor at the termination of the insulation.

3A702 Removal of Flux and Impurities

After solder has solidified and cooled, all flux and impurities shall be removed from each solder connection, using solvents as specified in Paragraph 3A311.

3A703 Connection Inspection

Prior to further processing, the quality of the soldered connections shall be determined by visual inspection. Magnifying glass 5X to 10X shall be used as an inspection aid, where applicable. Parts and conductors shall not be physically disturbed to aid inspection.

3A704 Acceptance Criteria

An acceptable solder connection will be characterized by:

1) Clean, smooth undisturbed surface

2) Concave fillet between conductor and termination

3) Contour of conductor visible

4) Complete wetting.

Note: For high-voltage or RF applications, variations from the above criteria will be in accordance with engineering requirements and shall take precedence over other requirements.

3A705 Rejection Criteria

The following are some characteristics of unsatisfactory solder conditions which are cause for rejection:

1. Conductors and Parts

a) Damaged, crushed, cracked, charred, melted, etc. (Normal thermal stripping heat marks are allowable)

b) Improper insulation clearance

c) Improper tinning

d) Separation of wire strands

e) Part improperly supported or positioned

f) Part marking not visible

g) Part damaged

h) Loose conductors

i) Cut, nicked, stretched or scraped leads or wires

j) Flux residue or other contamination

k) Improper wrap or stress relief.

2. Solder Connections

a) Cold joint

b) Overheated joint

c) Fractured joint

d) Bare copper or base metal

e) Improperly bonded joint

f) Pitted or porous joint

g) Excessive solder, points, or peaks

h) Insufficient solder

i) Splattering of flux or solder on adjacent areas

j) Rosin solder connection

k) Unclean connection (lint, flux, dirt, etc.)

l) Dewetting

m) Excessive wicking.

CHAPTER 8: PRINTED WIRING ASSEMBLY SOLDERING

3A800 Fabrication and Conformal Coating

Printed wiring boards shall be designed, fabricated and inspected in accordance with the requirements of the contract. The assembly of parts, soldering and inspection of the completed wiring assemblies shall be in accordance with the requirements specified herein.

3A801 General Requirements

1. Dip Soldering. Manual dip soldering of printed wiring assemblies is not permitted.

2. Pattern Repair. Repair of damaged or broken conductor patterns on printed wiring boards is not permitted unless covered by Government-approved Standard Repair Procedures.

3. Machine Solder Rework. Rework of machine soldered printed wiring assemblies shall be performed in accordance with the soldering requirements of this publication.

4. Gold Removal. Gold plating shall be removed from the printed board areas to be soldered prior to mounting of parts if the solderability requirements of MSFC-Proc-154 is not met. Removal shall not damage the copper conductor or add permanent contaminants to the insulating board. Boards shall be cleaned of contaminants before further processing.

5. Eyelets, Tubelets, and Plated-Through Holes

   a) Eyelets and tubelets shall not be used on printed wiring boards for circuit connections.

   b) When plated-through holes are used as an electrical connection between conductor patterns or double-sided boards, the engineering documents requiring such an installation will be made available for NASA/GSFC review and evaluation.

3A802 Printed Wiring Board Protection

During fabrication, inspection, handling and storage, the printed wiring board shall be suitably protected to prevent deformation, contamination, or damage.

3A803 Terminal Soldering

1. General. A V-type (funnel) swage shall be used on printed circuit boards where the swaged end of the terminal ends in a circuit pad or pattern. A roll-type swage shall not be used on the conductor pattern. Terminals shall not be used for interfacial connection. After swaging, the roll or flare shall conform to the following requirements:

   a) No more than two splits in the flare

   b) No radial split extending into the barrel

   c) No circumferential splits

   d) No part of the terminal missing

   e) Seated perpendicular to the board within $\pm 5^{\circ}$.

   Solder rings are recommended for use on swaged terminals to provide a uniform and reliable solder connection. The solder must be applied at all points of contact between the terminal and conductor pattern.

2. Swaging. When solder rings are used, the ring shall be placed over the terminal shank before swaging. A V-type (funnel) swage shall be made on the terminal, using a swaging tool as shown in Figure 8-1a. The point of the V-swage shall enter the terminal shank only far enough to produce a finger fit of the terminal (see Figure 8-1b).

3A804 Preparation and Soldering of Termination Areas

1. Termination Area. The termination area shall be clean prior to soldering. Soldering to printed wiring termination areas shall be to the base metal or to tin-lead coated base metal.

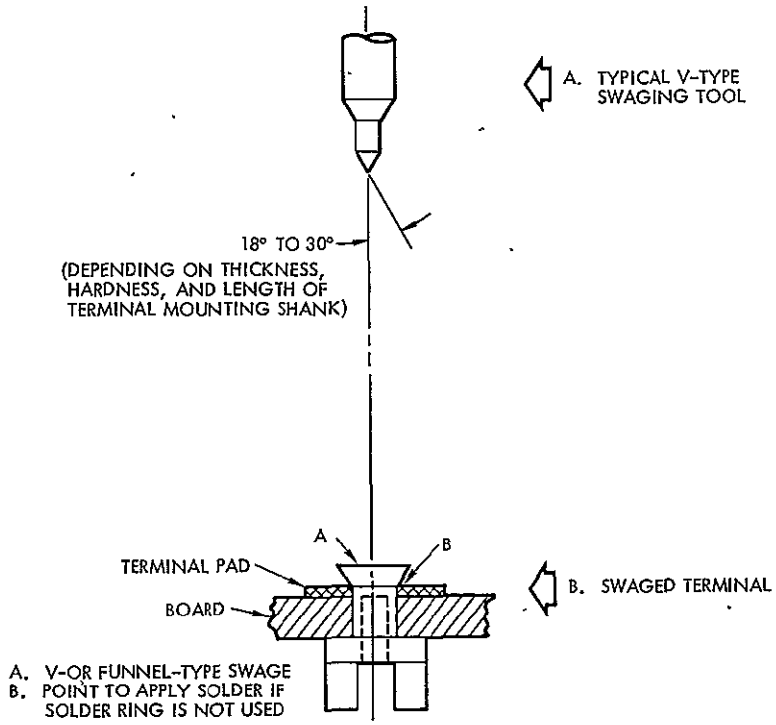

Figure 8-1

TYPICAL SWAGING TOOL AND SWAGED TERMINAL

2. Soldering to Termination Areas. The melted solder shall flow around the conductor and over the termination area so that a fillet is formed. The outline of the lead shall be visible in the finished connection. After soldering, flux residue and other contaminants shall be removed.

3A805 Inspection

Each completed printed wiring assembly shall be visually inspected to the criteria listed in paragraphs 3A806 and 3A807, and for other indications of poor workmanship or nonconformance to the design requirements. Magnification shall be using a 5X to 10X magnifier as an inspection aid. Higher magnification may be used for clarification of detail. For high-voltage or RF applications, variations

from paragraphs 3A805 and 3A806 will be in accordance with engineering requirements and shall take precedence over other requirements.

3A806 Acceptance Criteria

The following are characteristics of acceptable solder connections to printed wiring assemblies:

1) Clean, smooth, undisturbed surface

2) Regular, even fillet between conductor and termination area

3) Contour of conductor visible

4) Complete wetting.

3A807 Rejection Criteria

The following are some characteristics of unsatisfactory printed wiring assemblies which are cause for rejection:

1) Charred, burned, or melted insulation or parts

2) Conductor pattern separation from board

3) Burns on base materials

4) Excessive solder (including peaks, icicles, and bridging)

5) Flux residue, solder splatter, or other foreign matter

6) Dewetting, in areas of soldered joints

7) Insufficient solder (a small amount of exposed base metal around the periphery of the termination area or at the edge of a conductor is acceptable)

8) Pits, holes, voids, or exposed base metal in the soldered connection

9) Cold, rosin, disturbed, or fractured solder connection

10) Cut, nicked, gouged, or scraped conductors or conductor pattern

11) Improper conductor length or direction of clinch

12) Repaired or damaged conductor pattern

13) Blistered or wrinkled conductor pattern.

CHAPTER 9: AUTOMATIC MACHINE SOLDERING OF PRINTED CIRCUIT BOARDS

3A900 General

This section contains requirements peculiar to automatic machine soldering (wave soldering). General requirements including acceptance and rejection criteria specified in this publication are applicable.

3A901 Documentation

1. The supplier shall establish complete and detailed documentation for operation and maintenance of the soldering machines and their environment, and for inspection of both the process and the end products.

2. The documentation shall set limits on the:

   a) Preheat temperature

   b) Temperature of the solder

   c) Conveyor speed

   d) Height of the solder wave

   e) Control of the dross inhibition oil and flux (if fluxing is done as a machine step)

   f) Amount of contaminants permissible when the solder bath is analyzed

   g) Frequency of maintenance, analysis, and other factors affecting the quality of the connections in the end-product.

Maintenance and calibration data shall be recorded and available to Government and supplier inspection.

3A902 Preparation and Assembly

1. Only tin-lead (solder) coated and reflowed electro-plated tin-lead coated conductor patterns shall be used in machine soldering of printed wiring board assemblies.

2. Parts shall be mounted as specified in sections 5 and 6 of this document. The mounting shall prevent relative motion between part and board during solder solidification.

3. The assembled boards shall be clean immediately prior to loading onto the carrier.

4. Metal surfaces not to be soldered shall be masked or coated with a solder resist prior to loading.

5. Liquid flux specified in paragraph 3A310 shall be applied.

3A903 Machine Requirements

1. The preheat temperature shall be controlled to a selected temperature between 160° and 250°F. The selected temperature shall be maintained within ±5°F.

2. The conveyor speed shall be controlled to a preselected rate, which shall not vary more than 1 inch per minute.

3. Solder temperature shall be controlled so that the solder in the wave-making contact with the board is 500°F ± 10°F.

4. The oil used as a dross inhibitor shall have a flash point higher than the maximum solder temperature.

5. The height of the solder wave shall be controlled to a constant preselected height.

6. The solder bath shall be chemically analyzed periodically for conformance with the requirements of paragraph 3A309, except that copper content shall not exceed 0.2%.

3A904 Cleaning

After soldering, flux and dross inhibitor oil shall be promptly removed in a manner which does not damage the hardware.

3A905 Inspection

Inspection criteria listed in section 8 are applicable to machine soldering assemblies. Warp or twist of the board shall not exceed the limits specified by the detail drawing.

APPENDIX A

GLOSSARY

Article	A unit of hardware or any portion thereof required by the contract.
Bifurcated (split) terminal	A terminal containing a slot or split in which wires or leads are placed before soldering
Certification	The act of competent authority in verifying and documenting that personnel have completed required training, demonstrated specified proficiency, and met other specified requirements.
Cold solder connection	Unsatisfactory connection resulting from dewetting and exhibiting an abrupt rise of the solder from the surface being soldered.
Conduction soldering	Method of soldering which employs a soldering iron for transfer of heat to the soldering area.
Conductor	A lead or wire, solid or stranded serving as an electrical connection between terminals.
Conformal coating	A thin protective coating which conforms to the configuration of the covered assembly.
Cordwood construction	Circuitry in which parts are mounted between and normally perpendicular to, two printed wiring or conductive networks.
Deviation	Any nonconformance to drawing or specification requirements which, in the opinion of TRW Systems Group quality assurance does adversely affect safety, weight, interchangeability, service life, reliability, performance, or the basic requirements of the contract.
Dewetting	The condition in a soldered area in which the liquid solder has not adhered intimately, characterized by an abrupt boundary between solder and conductor or solder and terminal/ termination area.
Disturbed solder connection	Unsatisfactory connection resulting from relative motion between the conductor and termination during solidification of the solder.
Electrical connection	Connections in electrical or electronic circuits.
Excessive solder connection	Unsatisfactory connection wherein the solder obscures the configuration of the connection.

Eyelet	A tubular metal part having both ends headed or rolled over
Fractured joint	A solder joint in which the solder has fractured or broken between the joint elements.
Hook terminal	A terminal formed in a hook shape.
Mission essential support equipment	Mission-essential support equipment is defined as satisfying any of the following: 1. Equipment used in a closed loop with the system where failure would degrade the mission or imperil personnel. 2. Equipment used when transferring toxic or explosive fluids in which failure could result in personnel hazards or affect mission success. 3. Equipment used as a last check prior to installation whose failure would result in lowering the probability of mission success or compromising personnel safety.
Part lead	The wire, solid or stranded, which extends from and serves as a connection to a part.
Part	One piece, or two or more pieces joined together which are not normally subject to disassembly without destruction of designed use. Synonomous with detail part and component part (e.g., resistor, capacitator, valve, and relay).
Potting compound	A nonconductive compound used for encapsulation of parts, conductors, or assemblies.
Pierced (perforated) terminal	A terminal containing a hole through which leads or wires are placed before soldering.
Pits	Small holes or sharp depressions in the surface of the solder.
Repair	Operations performed on a nonconforming article to place it in usable and acceptable condition. Repair is distinguished from rework.
Resistance soldering	Method of soldering by passing a current between two electrodes to heat the area to be soldered.

Rework	The reprocessing of articles or material which will make it conform to drawings, specification, or contract.
Rosin flux	A noncorrosive, nonconductive, chemically active compound capable of promoting the wetting or metals with solder.
Rosin solder connection	Unsatisfactory connection which has trapped flux.
Overheated joint	An unsatisfactory solder joint characterized by rough solder surface.
Solder	A nonferrous, fusible metallic alloy used when melted to join metallic surfaces.
Solder cup terminal	A hollow, cylindrical terminal to accommodate one or more conductors.
Soldering	The process of joining metallic surfaces through the use of solder without direct fusion of the metals.
Straight pin terminal	A round post-type smooth terminal with no grooves, slots, or guides.
Supplier	A contractor or subcontractor actually performing the services or producing the contract articles.
Terminal	A tie point device used for making electrical connections.
Termination	The point at which an electrical conductor ends usually at an electrical connection.
Termination area	A conductive surface on a printed wiring board used for making electrical connections (also referred to as printed circuit pad).
Thermal shunt	A device with good heat dissipation characteristics used to conduct heat away from an article being soldered.
Tinning	The coating of a surface with a uniform layer of solder before it is used in a soldered connection.
Tubelet	A tubular metal part with both ends formed in a conical flare of approximately 90 degrees included angle.

Turret terminal	A round post-type grooved stud around which conductors are fastened before soldering.
Variation	Any conformance to drawing or specification requirements which, in the opinion of TRW Systems Group quality assurance does not adversely affect safety, weight, interchangeability, service life, reliability, or performance.
Waiver	Granted use or acceptance of an article which does not meet specified requirements.
Wetting	Adhesion of a liquid to a solid surface.
Wicking	The flow of molten solder by capillary action.

APPENDIX B

TRW SYSTEMS GROUP — Electronic Systems Division

ELECTRONIC HARDWARE OPERATIONS

STANDARD OPERATING PROCEDURE

NUMBER	
2.10.1	
EFF. DATE	REV.
1/3/69	
PREPARED BY	
J. P. White	

SUBJECT: TRAINING PROGRAM – NASA SOLDERING

APPROVED _____

1. PURPOSE AND SCOPE

- To provide a program which will train and/or qualify personnel for soldering of electrical connections to meet the requirements of NASA document NHB5300.4(3A).
- This training is mandatory for all personnel who are involved with soldering or inspection of soldering on deliverable flight hardware for NASA contracts.

2. GENERAL

- The NASA Solder School is designed to train and/or certify personnel in a 40 hour course. Experienced personnel may satisfy the requirements in less time; however, bypassing of prescribed course content is not permitted.
- Students are required to read course material, practice soldering techniques, demonstrate proficiency by making samples of solder joints, analyze the samples prior to submitting them to the instructor, rework unacceptable samples, take brief daily written exams, and pass a final written exam. Each individual is encouraged to work at his own pace.

3. POLICY

- Achievement of Certified Status – Personnel will be certified on meeting these qualifying requirements satisfactorily.

  Visual Acuity – All personnel shall initially and annually be tested to meet the requirements listed below. Failure to meet any of the following requirements shall disqualify a candidate for training and certification:

  a) Far Vision – Sneelen chart 20/50, or better.

  b) Near Vision – Jaeger 1 or 0.50 meters at 14 inches or better, or reduced Snellen 20/20 or equivalent.
  NOTE: Vision not meeting items a. or b. shall be corrected by prescription lenses.

  c) Color Vision – Ability to distinguish red, green, blue and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, or AOD-HRR tests. A practical test, using color coded electrical parts as applicable, will be acceptable for color vision testing.

  d) Depth Perception – Normal for fine, close work as determined by standard testing methods.

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A minimum grade of 80% on a written examination at the conclusion of the course on the applicable requirements of NHB5300.4(3A).

Demonstration of acceptable proficiency on training school samples.

- Maintenance of Certified Status — Based on a quality audit, review of inspection data (per SOP 6.2.6) or observation of the quality of articles fabricated.

  Soldering personnel involved may be required by Manufacturing Supervision, Quality Assurance, or by the procuring installation or its designated representative to demonstrate proficient workmanship on applicable hardware, or to be recertified.

  Inspection personnel involved may be required by the procuring installation or its designated representative to demonstrate proficient inspection performance and knowledge on applicable hardware, or to be recertified.

- Recertification — Recertification of personnel is required when any of the following conditions exist:

  One year has elapsed since prior certification/recertification

  Certification has been revoked and/or quality has degraded

  Certificate holder changes employment

  An employee's assignment involves new techniques which have been developed and which require special skills.

- Certification of soldering personnel will be initiated on an annual basis (within 30 days of certificate issue or renewal) when the following conditions are met before certificate expiration date:

  The individual's annual visual acuity test has been performed and approved by the Health and Safety Department.

  Re-examination and certificate renewal is requested by the operator's supervisor or by the inspector's supervisor.

- An employee who registers for recertification shall not be required to complete the entire initial certification course outline, but shall be required as a minimum to demonstrate proficiency in soldering the most difficult of each of the five categories of samples and to pass a written examination.

- Revocation of Certified Status — Certificates shall be revoked for operators or inspectors when:

  The requirements for "Maintenance of Certified Status" or "Recertification" have not been fulfilled.

The Supplier training program fails to meet the requirements of NASA document NHB5300.4(3A).

The certificate holder leaves employment.

4. RESPONSIBILITIES

- Standards and Training Section, Manufacturing Engineering Department, is responsible to:

  Maintain a documented training program which meets the requirements of NHB5300.4(3A).

  Instruct personnel by a qualified NASA instructor/examiner

  Provide space, equipment and tooling required for the course

  Use only tooling and equipment that has been calibrated in compliance with SOP 2.6.1

  Maintain course and certification records

  Determine, subject to QA Staff Certification Group approval, whether or not an applicant has satisfied all requirements for certification, including a thorough understanding of NASA soldering principles, a demonstrated proficiency in the application of these principles, and a passing grade in a written examination

  Notify Manufacturing and Inspection Supervision at least 30 days prior to expiration of an employee's certification

  Issue a certification card to individuals who satisfy the course requirements

  Notify Manufacturing and Inspection Supervision of the certification status of all personnel (certified, failed, revoked).

- Quality Assurance Staff Certification Group is responsible to:

  Review, approve and monitor the course

  Approve or reject the "pass" or "fail" recommendation of the course instructor/examiner

  Approve certificates for those employees who have satisfied course requirements.

- Manufacturing and Quality Inspection Supervision are responsible to:

  Notify the Training Office at least 5 working days prior to a course start date that present or newly hired employees require certification/recertification due to a planned involvement in a NASA contract

Obtain eye examinations for employees

Provide training budget for instructors and employees enrolled in the course.

5. PROCEDURE

- Initial Certification

The responsible supervisor shall request registration for those personnel who will be involved with soldering on a NASA contract. Registration may be completed and a course start date determined by contacting the Manufacturing Engineering Department Training Program Office clerk,

The supervisor shall be responsible for sending the registrant to the Health and Safety Office for an eye examination at least three days 1 prior to the course start date.

The Health and Safety Department shall be responsible for performing the eye examination, initiating a Personnel Training/Certification Record (Systems Form No. 3230) which contains the results of the eye examination, retaining the green copy of the form, and forwarding all other copies to the Training Program Office.

If the eye examination requirements have not been satisfied, the Training Program Office shall immediately notify the employee's supervisor that the employee cannot be permitted to attend the course and, consequently, cannot be utilized on a NASA Program.

If the eye examination requirements have been satisfied:

a) The employee will report to the NASA Solder Training School location at 7:30 a.m. on the date scheduled. All supplies and equipment shall be furnished by the school.

b) The Personnel Training/Certification Record form shall be forwarded by the Training Program Office clerk to the NASA Solder School Instructor/Examiner pending completion of the course, at which time the course results shall be entered in the Training/Examination section of the form by the Instructor/Examiner and forwarded to the Training Office clerk.

The Training Office clerk shall file or distribute the copies of the Training/Certification Record form as follows:

White copy	-	To QA Staff Certification Group
Blue copy	-	Training Program recall file by date
Pink copy	-	Training Program file by employees badge number
Goldenrod copy	-	Employee Department Manager

The Instructor/Examiner shall initiate and approve a Personnel Certification Form (Systems Form 3555) for those employees who have satisfied the course requirements, and shall submit training work samples and test results to the QA Staff Certification Group.

The QA Staff Certification Group shall review the employee's work samples and examination results and approve or reject the recommendation of the Instructor/Examiner.

If the Personnel Certification Form receives the approval of both the Instructor/Examiner and QA Staff, it will be forwarded to the Training Office clerk, who will file or distribute the copies of the form as follows:

"Tear Off" Copy	-	To the Certified Employee
White Copy	-	Training Office file by employee badge number
Yellow Copy	-	Employee Department Manager
Pink Copy	-	Extra copy
Hard Copy	-	QA Staff Certification Group

If the employee fails to receive approval of satisfactory course completion, the supervisor will be informed by the Training School Office clerk.

- Recertification

The Training Program Office clerk shall initiate monthly, a list of all personnel whose certification is due to expire during the following month. Distribution shall be as follows:

All Manufacturing Product Line Managers
Quality Inspection Department Managers
Quality Assurance Staff Certification Group
Personnel Office

The same procedure and responsibilities as defined in "Initial Certification" shall be adhered to for Recertification.

6. REFERENCES

- NHB5300.4(3A) - Requirements for Soldered Electrical Connections (NASA Publication).
- SP-5002 - 4th Edition (NASA Publication).
- Soldering Training Program Guide (Published by NASA, Marshall Space Flight Center, Huntsville, Alabama).
- SOP 6.2.6— Product Evaluation and Corrective Action
- SOP 2.6.1— Property Planning, Acquisition and Control

[illegible]
SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CODE IDENT 11982

TITLE

DISCRETE COMPONENT INSTALLATION AND SOLDERING TO TERMINALS

DATE 30 July 1969 NO. FIPP- 7-18-02

SUPERSEDING: NEW

PROJECT: ALL

PREPARED BY:

Harold Mandel 7/29/69
MANUFACTURING ENGINEERING DATE

[illegible] 7/29/69
PRODUCT ASSURANCE DATE

A.R. Brown 8/1/69
MATERIALS AND PROCESSES DATE

APPROVED BY:

[illegible] 7/30/69
MANUFACTURING ENGINEERING DATE

[illegible] 8/4/69
PRODUCT ASSURANCE DATE

[illegible] 8-1
MATERIALS AND PROCESSES DATE

[redacted] SYSTEMS GROUP	FABRICATION/INSPECTION PROCESS PROCEDURE
TITLE: Discrete Component Installation and Soldering to Terminals	FIPP- 7-18-02

REVISION RECORD

REV.	DATE	AUTHORIZATION	PAGES EFFECTED	CHANGE
	8-4-69	R S Hinny		Initial Issue

[redacted] SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
TITLE: Discrete Component Installation and Soldering to Terminals	FIPP-7-18-02	REV: NC	INDEX

1. Equipment, Tools, and Materials Page 1
2. General Requirements 2
3. Process Sequence 3
   3.1 Discrete Components (Excluding Transistor Cans) 3
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TI SYSTEMS GROUP	FABRICATION/INSPECTION PROCESS PROCEDURE		
TITLE: Discrete Component Installation and Soldering to Terminals	FIPP- 7-18-02	REV: NC	
NOTE: This procedure is in accordance with the requirements of PR 3-5E, PR 3-21A, PR 7-1G, PR 7-16B.			
FABRICATION INSTRUCTIONS			INSPECTION INSTRUCTIONS

1. EQUIPMENT, TOOLS AND MATERIALS

Soldering Iron, Hexacon "Miniron" Model No. 21A or Hexacon Model No. 25S (with three (3) wire grounded cable system) or equivalent.

Soldering Tip, 1/16 x 1/64 inch chisel tip, Durotherm Model HT361D, or as applicable to size and shape of metal parts.

Powerstat, Type 116B 50/60 IPH, Superior Electric

Heatsinks (Thermal Shunts)

Cutters, Diagonal

Lint-Free Cotton Gloves or Finger Cots

Pliers, Long-Nose (rounded edges, without serrations)

Safety Goggles

Tweezers, Clauss A-A

Sponge, Tip Cleaning

Brushes, Kimwipes, Q-Tips

Holding Fixture as Specified by MSO.

Isopropyl Alcohol (TT-I-735)

Squeeze Bottle

Solder, QQ-S-571, Sn 63, WRMAP2,

[redacted] SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
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FABRICATION INSTRUCTIONS	INSPECTION INSTRUCTIONS

Flux per MIL-F-14256, Type A, Alpha Metals 611.

NOTE: For substitutions of the above listed items, contact Manufacturing Engineering.

2. GENERAL REQUIREMENTS — AUDIT

2.1 Operators and Inspectors must have a valid Certification Card for Soldering. — Check Certification Cards of Operators and Inspectors.

2.2 Manufacturing Engineering must be consulted for proper soldering iron temperature setting.

2.3 The work station must be equipped with the required tools and materials. Condition of tools and materials must be verified daily.

2.4 Safety goggles should be worn when cutting wires, soldering, or using solvent.

2.5 Soldering iron should be placed in a location that will not require reaching across or around it.

2.6 When cutting wires, the open side of the cutter should be kept away from the body and pointed down. Cuttings should be removed from the work area after completing each set of operations.

2.7 Components to be processed must be prepared for soldering per FIPP-3-21-01.

SAFETY PRECAUTIONS: Women working in an area where soldering operations are performed should wear closed, low-heeled shoes and smocks.

2.8 When bonding of components is required, perform per MSO.

TRW SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
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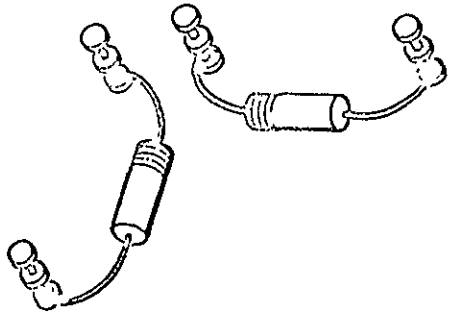
FABRICATION INSTRUCTIONS	INSPECTION INSTRUCTIONS
3. PROCESS SEQUENCE	END ITEM
NOTE: Place board in holding fixture as specified on MSO. Handle by the edges with finger cots or clean, lint-free gloves to prevent contamination. Do not touch board surface with bare skin.	Inspection may be aided by optical devices up to 10X magnification maximum.
3.1 Discrete Components (Excluding Transistor Cans)	Check drawing(s) applicable to the assembly, including Engineering Orders (E.O's)
3.1.1 Review the Engineering Drawing or Visual Aid(s). Unless polarity requirements indicate otherwise, component markings or color codings should read uniformly; for example, left to right and top to bottom.	Handle by the edges with finger cots or clean lint-free gloves. Do not touch board surface with bare skin.

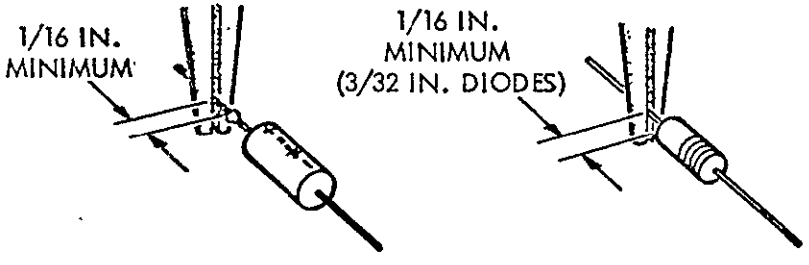


TRW SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
TITLE: Discrete Component Installation and Soldering to Terminals	FIPP- 7-18-02	REV: NC	

FABRICATION INSTRUCTIONS | INSPECTION INSTRUCTIONS

3.1.2 With long-nose pliers, firmly but gently grip component by one lead, 1/16 inch from the body (3/32 inch for diodes). For leads with welds (tantalum capacitors) grip 1/16 inch beyond lead weld.

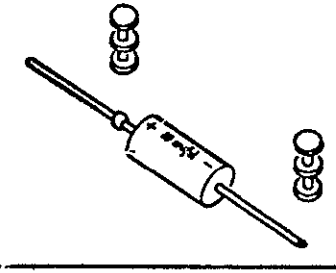
NOTE: Be sure not to damage body or seal. Whenever practical, avoid picking up component by the body.



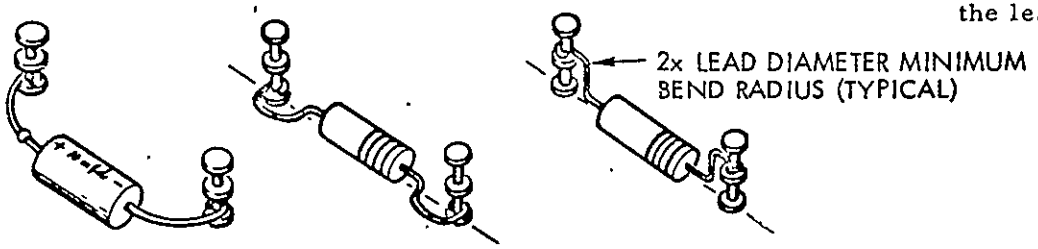
3.1.3 Examine leads. If leads are discolored and have obvious contamination, set component aside and notify your Supervisor.

3.1.4 Turn component until marking faces up.

3.1.5 Space component evenly on the board between the terminal attachment points. Whenever Engineering Drawing permits, position off-center to allow for lead strain relief.



FABRICATION INSTRUCTIONS	INSPECTION INSTRUCTIONS
	END ITEM INSTALLATION
3.1.6 When components are to be mounted in clamps, press component body into clamp. If the clamp is too tight, too loose, or has burrs, stop and notify your Supervisor.	Verify that components are seated in clamp.
3.1.7 While still holding lead, with pliers carefully form the lead to the connection point. CAUTION: Be sure that component marking faces up. Do not damage component body, body seal, lead weld, or lead. When sharp bends are required, do not make bend smaller than twice the lead diameter.	Verify that lead bends start no closer than 1/16 inch from component body or lead weld (3/32 inch for diodes). Verify lead strain relief. Minimum bend radius is twice the lead diameter or greater.



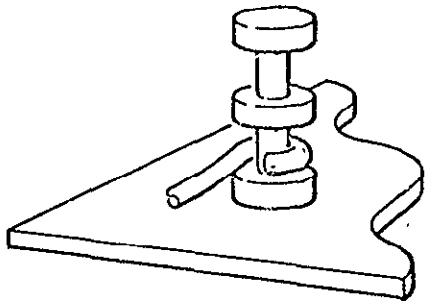
3.1.8 Lead Connections NOTE: Do not overlap one lead over another. CAUTION: Examine Engineering Drawing or Visual Aid(s) to note total number of connections to each point. Those areas that require jumper wires may be required to have lead connections at the lower part of the terminal. External wiring may require connections at the higher part of the terminal. Unless otherwise specified, only three (3) wires are to be connected per section.	Verify lead connections per 3.1.8 unless otherwise specified on Engineering Drawing.

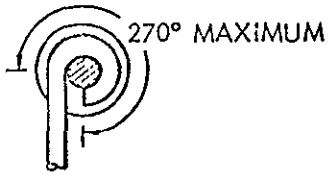
[illegible] SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
TITLE: Discrete Component Installation and Soldering to Terminals	FIPP- 7-18-02	REV: NC	
FABRICATION INSTRUCTIONS			INSPECTION INSTRUCTIONS

3.1.8.1. Post-Type Terminals

While firmly but gently holding lead between component body and terminal, wrap lead around part of the terminal that is available. Unless otherwise specified by Engineering Drawing, wrap 180 degrees. Cut off lead end at edge of terminal and crimp end to post. Wrap should not exceed 270 degrees.

NOTE: Wire that is 28 AWG or smaller may be wrapped 180 degrees to one full turn around terminal.



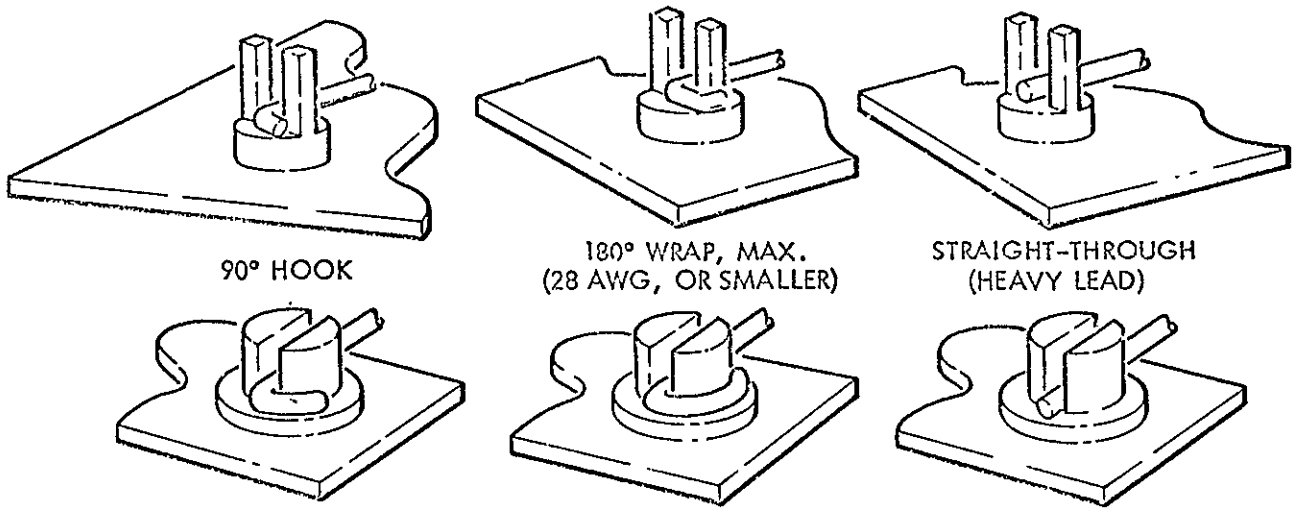


3.1.8.2 Slotted (Bifurcated) Terminals

While firmly but gently holding lead between component body and terminal, place the lead in the slot against one side. Unless otherwise specified by Engineering Drawing, make a 90-degree hook or wrap. Cut off lead end at edge of terminal. Crimp lead end to terminal.

NOTE: Wire that is 28 AWG or smaller may be wrapped 90 to 180 degrees.

CAUTION: If the lead is too heavy compared to the size of the terminal and wrapping may cause damage, preform 90 degree hook to fit in slot and hook to terminal(s). MSO or Visual Aid may specify to pass the lead through the slot without wrapping. Cut off lead end at edge of terminal.

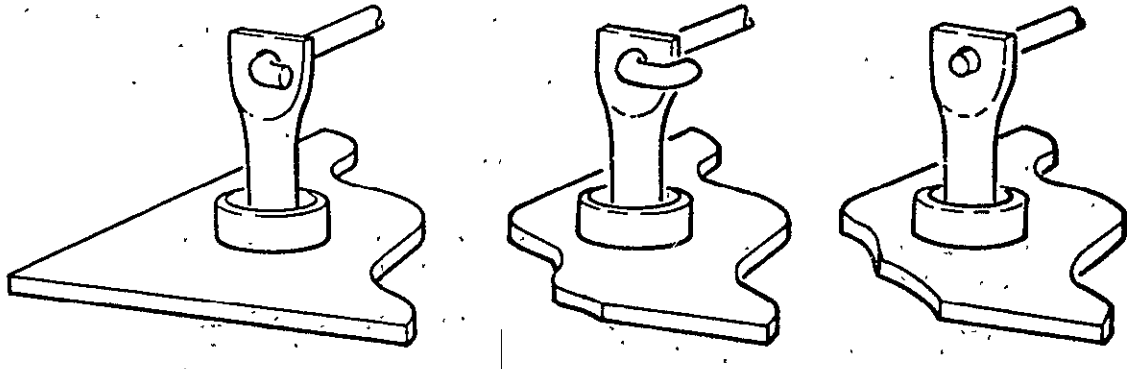


3.1.8.3 Perforated (Pierced) Terminals

While firmly but gently holding lead between component and terminal, pass lead through hole or slot of terminal and make a 90-degree hook or wrap, unless otherwise specified by Engineering Drawing. Cut off lead end at the edge of terminal.

NOTE: Wire that is 28 AWG or smaller may be wrapped 90 to 180 degrees.

CAUTION: If lead is too heavy compared to the size of the terminal and wrapping may cause damage, preform a 90 degree hook. Pass through hole without wrapping. Cut off lead end at edge of terminal. MSO or visual aid may specify to pass the lead through the hole without hook.



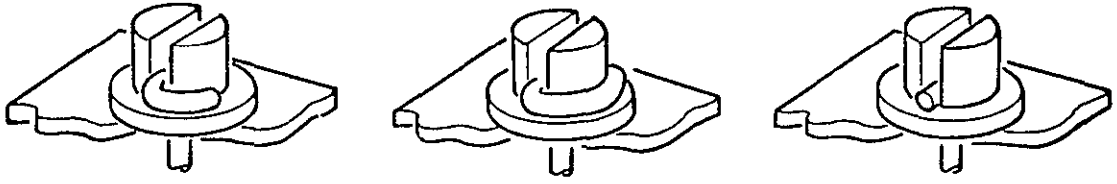
90° HOOK | 180° WRAP, MAX. (28 AWG, OR SMALLER) | STRAIGHT-THROUGH (WHEN SPECIFIED)

3.1.8.4 Through-Hole Connections

Through-holes of terminals may be specified for lead connection for terminals of 3.1.8.1 or 3.1.8.2. If the connection is to be straight through, the lead end must be visible after cut off.

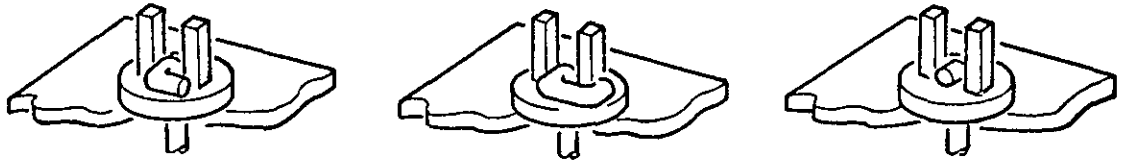
For post type terminals, pass lead through hole. Bend 90 degrees or wrap 180 degrees to 270 degrees as applicable to terminal design.

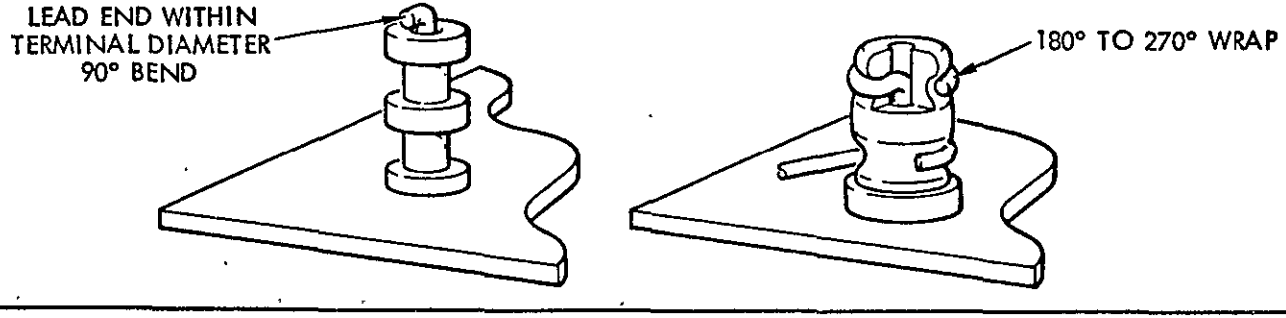
For slotted terminals, pass lead through hole, bend 90 degrees and locate in slot. Wire that is 28 AWG or smaller may be wrapped from 90 to 180 degrees.



28 AWG, OR SMALLER WIRE
ADDITIONAL 90° OR 180° WRAP

NORMAL CONNECTION
ONE 90° BEND





3.1.9 Use soldering iron that has been heated for at least five (5) minutes at a Powerstat setting in accordance with Manufacturing Engineering instructions.

3.1.10 Solder coat soldering iron tip for soldering. Clean tip by wiping on a wet sponge.

3.1.11 Review work to be performed.

CAUTION: Use heat sinks to prevent other solder joints from being affected in the process of soldering. Handle with care.

3.1.12 Carefully apply clean soldering iron tip to lead and terminal. Add just enough solder to form fillet between lead and terminal without obscuring lead or terminal contour. Do not exceed five (5) seconds.

CAUTION: Press iron just enough to make contact. The soldering iron should flow the solder within three (3) to five (5) seconds.

NOTE: In all cases, the lead end shall be coated by the solder. If lead or lead end will not accept solder, notify your Supervisor.

3.1.13 Allow the heated parts to cool.

3.1.14 Clean soldering iron tip by wiping on a wet sponge.

3.1.15 Repeat 3.1.1 through 3.1.14 for other lead.

3.1.16 Remove flux from soldered area with Q-tip dampened with isopropyl alcohol.

3.1.17 Wipe dissolved residue with a Kimwipe until dry.

3.1.18 Repeat 3.1.1 through 3.1.17 until other components of this section have been installed and soldered.

CAUTION: Do not allow flux to dry. Upon completion of solder operations, the board must be thoroughly cleaned for flux removal within two (2) hours. Clean per FIPP 2-22-01.

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FABRICATION INSTRUCTIONS

INSPECTION INSTRUCTIONS

Installation of Transistor Cans (TO-5, TO-18, TO-46, etc.)

3.2

NOTE: Lead connections and soldering instructions described below are also applicable to other transistor types. For specific installation information of other transistor types, consult Engineering Drawing or Visual Aid(s). If installation information is not available, contact Manufacturing Engineering.

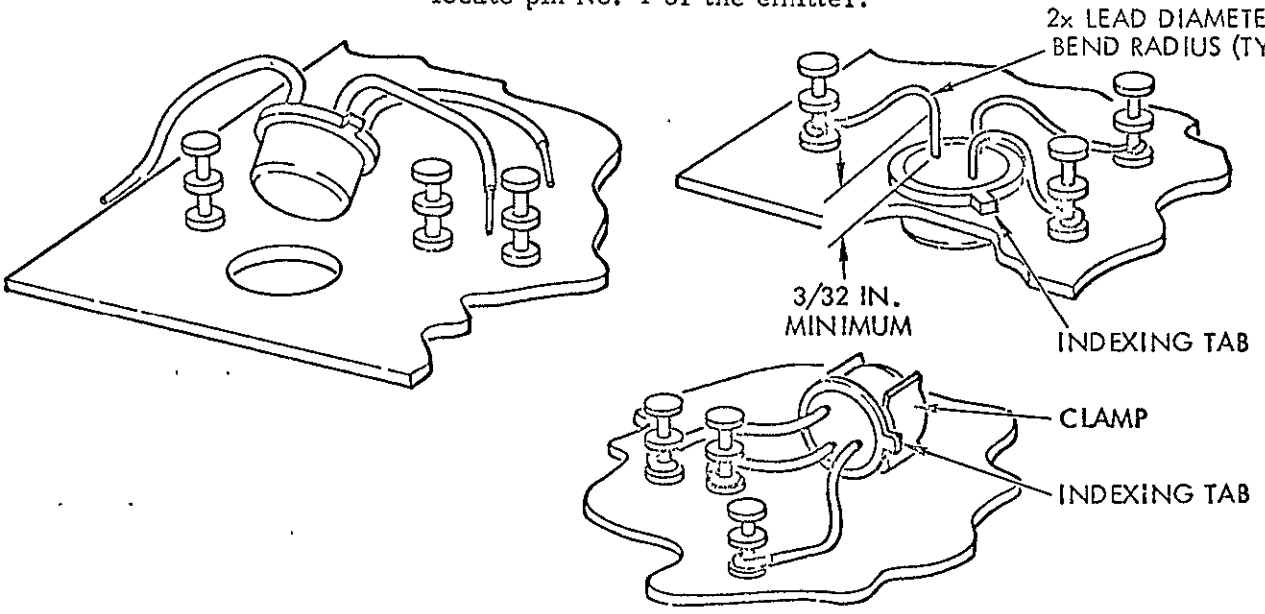
3.2.1 Review Engineering Drawing or Visual Aid(s). Check to see if the transistor is to be mounted with a transipad and that transipad is available. Check to see if insulation, when required, is on transistor leads.

3.2.2 Carefully pick up transistor and install on board. Typical mounting methods for transistor are as shown.

CAUTION: Make sure that the indexing tab is positioned to locate pin No. 1 or the emitter.

END ITEM: INSTALLATION

Verify that the indexing tab is positioned per Engineering Drawing.



TRW SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
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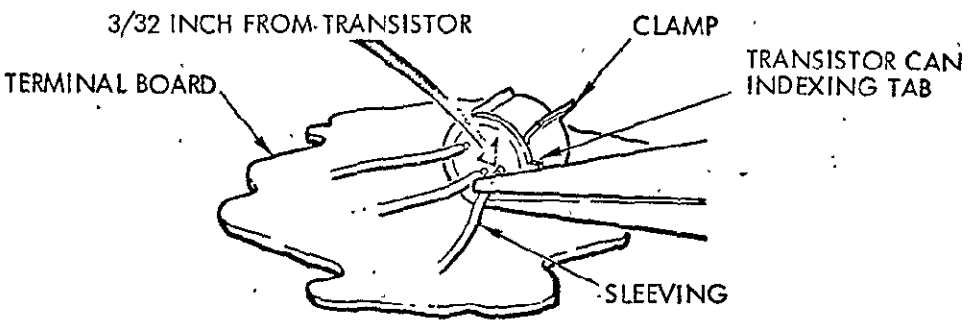
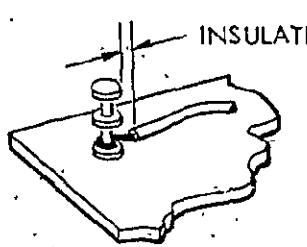
FABRICATION INSTRUCTIONS	INSPECTION INSTRUCTIONS
	END ITEM: INSTALLATION
3.2.3 When transistors are to be mounted in clamps, press transistor body into clamp. If the clamp is too tight, too loose, or has burrs, stop and notify your Supervisor.	Verify that transistor is seated in clamp.
3.2.4 With long-nose pliers, grip lead no closer than 3/32 inch from the body. Gradually form the lead to the connection point, then carefully grip lead near the connection point. Connect per 3.1.8.	Verify that transistor lead bend starts no closer than 3/32 inch from body.
CAUTION: Allow lead slack for strain relief. Be careful not to damage transistor body, lead seal, or lead. When sharp bends are required do not make smaller than twice the lead diameter.	Verify lead strain relief. Minimum bend radius is twice the lead diameter or greater.



3.2.5 For sleeved transistor leads, make sure that the sleeving does not enter into solder joint. Maximum insulation gap is two (2) sleeving diameters, providing the unsleeved portion does not touch other conductors or parts.	Insulation does not enter into solder joint and unsleeved portion does not touch other conductors or parts.



TRW SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
TITLE: Discrete Component Installation and Soldering to Terminals	FIPP-7-18-02	REV: NC	

FABRICATION INSTRUCTIONS	INSPECTION INSTRUCTIONS
3.2.6 Use soldering iron that has been heated for at least five (5) minutes at a Powerstat setting in accordance with Manufacturing Engineering instructions.	
3.2.7 Solder coat soldering iron tip for soldering. Clean tip by wiping on a wet sponge.	
3.2.8 Review work to be performed.	
CAUTION: Use heat sinks to prevent other solder joints or printed wiring from being affected in the process of soldering.	
3.2.9 Carefully apply clean soldering iron tip to lead and terminal. Add just enough solder to form fillet between lead and terminal without obscuring lead or terminal contour. Do not exceed five (5) seconds.	END ITEM: SOLDER Continuous solder fillet between lead and terminal.
CAUTION: Press iron just enough to make contact. The soldering iron should flow the solder within three (3) to five (5) seconds.	Lead contour visible through the solder.
NOTE: In all cases, the lead shall be coated by the solder. If lead or lead end will not accept solder, contact your Supervisor.	Lead end coated with solder.
3.2.10 Allow the heated parts to cool.	No disturbed joints (rough, granular, or cracked surface) or cold joint.
3.2.11 Clean soldering iron tip by wiping on a wet sponge.	No dewetting in solder area.
	No foreign materials in solder.
	No pitting of solder joint.

[redacted] SYSTEMS	FABRICATION/INSPECTION PROCESS PROCEDURE		
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FABRICATION INSTRUCTIONS	INSPECTION INSTRUCTIONS
3.2.12 Repeat 3.2.1 through 3.2.11 for other leads. 3.2.13 Remove flux from soldered area with Q-tip dampened with isopropyl alcohol. 3.2.14 Wipe dissolved residue with a Kimwipe until dry. 3.2.15 Repeat 3.2.1 through 3.2.14 until other transistors have been installed and soldered. CAUTION: Do not allow flux to dry. Upon completion of solder operations, the board must be thoroughly cleaned for flux removal within two (2) hours. Clean per FIPP-2-22-01.	END ITEM: DAMAGE Check for damage to component body, lead seal, lead weld, or lead. Check for damage to board, printed wiring terminals, insulation, and other parts. Check for board delamination or blistering. Note: Measling or crazing is not delamination or blistering; measling and crazing are acceptable.

EARTH RESOURCES TECHNOLOGY SATELLITE FINAL REPORT
10. SOLDERING PROGRAM PLAN